# *IS-IS: A Brief Introduction*

Intermediate System-to-Intermediate System, or IS-IS, is an interior routing protocol or an Interior Gateway Protocol (IGP). Developed in the 1980's, IS-IS was intended to be the routing protocol for OSI in an attempt to produce a standards protocol suite that could allow internetworks generous scalability.

At that time, the need was identified for

- A non-proprietary protocol
- A large addressing scheme
- A hierarchical addressing scheme
- A protocol that was efficient, allowing for fast, accurate convergence and low network overhead

The intention was to create one protocol suite that every system in the world could use. It became a race between TCP/IP and OSI. In an initiative called the Government Open Systems Interconnections Profile (GOSIP), the United States determined that every system operated by the government had to be capable of running OSI architecture. In the end, however, the initiative failed. The practical alternative was the Internet, built on TCP/IP—after all, it was there, and it worked.

Of late, IS-IS has been taken from the shelf, dusted off, and put into use.

## IS-IS Terminology

The terminology used by IS-IS may seem complex, if not absolutely alien. However, while the jargon may be unfamiliar, the concepts behind it are not.

The following list contains some commonly used IS-IS terminology, described in brief:

**Adjacency**: Local routing information that shows the reachability of an ES or IS over a single circuit. A separate adjacency is created for each neighbor on a circuit and for each level of routing (i.e., level 1 and level 2) on a broadcast circuit.

**Administrative domain**: Routers that share the same routing protocol within one organization.

**Area**: A routing subdomain within the Administrative Domain that maintains detailed routing information about its own internal composition. It also maintains routing information that allows it to reach other routing subdomains or areas. The area address is contained in the NET address.

**Circuit**: The local routing information for a single Subnet Point of Attachment (SNPA).

**CLNP (Connectionless Network Protocol)**: This is the protocol used to carry data and error indications on the network. It is similar to IP. Like IP it has no facilities to detect errors in data transmission, relying on the transport layer to provide these services.

**CLNS (Connectionless Network Service)**: Uses a datagram transfer service and does not require a circuit to be established before data is transmitted. While CLNP defines the actual protocol, CLNS describes a service provided to the transport layer with a service interface to CLNP. Being a connectionless service, it provides a "best effort" delivery. There is, therefore, no guarantee that data will not be lost, corrupted, misordered, or duplicated. If guaranteed delivery is required, the transport or application layer needs to provide the service that will correct the problems when they arise. CLNS and CLNP are terms that are often used interchangeably to mean the protocol that carries data through the OSI network.

**CSNP (Complete Sequence Number Packets)**: CSNPs describe every link in the link state database. They are sent on point-to-point links when the link comes up to synchronize the link state databases. The designated router (DIS) on a multicast network will send out CSNPs every 10 seconds.

**CLV (Code/Length/Value)**: These are the variable-length fields in a PDU. The Code specifies the information in the content field as a number. The Length states the size of the value field. The Value field contains the information itself.

**DIS (Designated Intermediate System)**: The router (IS) on a LAN that is designated to perform additional duties. In particular, it generates link state PDUs on behalf of the LAN by treating the LAN as a pseudonode.

**Dual IS-IS**: IS-IS that supports both OSI and IP routing information. Areas within the autonomous system may run OSI, IP, or both. However, the configuration chosen must be consistent within the entire area.

**ES (End System)**: The end node or host, which has limited routing capabilities. It has the OSI or IP layer 3 protocol running and can receive and send data.

**ES-IS (End System to-Intermediate System)**: The protocol by which the OSI ES (End System or host) and the IS (Intermediate System or router) communicate to dynamically learn layer 2 adjacencies.

**Hello**: The protocols that maintain the link and, thus, the adjacency between systems.

**Integrated IS-IS**: Another term for Dual IS-IS.

**IS (Intermediate System)**: System capable of routing traffic to remote destinations.

**IS-IS (Intermediate System-to-Intermediate System)**: The routing protocol that learns the location of the remote networks so that traffic may be forwarded to the end destination.

**IS-IS domain**: Routing within an organization that uses IS-IS as the single routing protocol.

**Level 1 (L1)**: These routers are internal to the area, which means that they know how to get to every network within the area and where to send traffic that is destined for another area. However, they have no knowledge of other areas' networks.

**Level 1-2 (L1-2)**: A router that connects areas. It will have a routing table for each area to which it is connected.

**Level 2 (L2)**: These routers are the same as L1 routers, in that they are internal. The difference is that their area is responsible for all the transit traffic between areas.

**Link**: A physical connection to a neighbor. The status of this link is the transmitted to all the other routers in the area in the LSP.

**LSP (link state packet)**: A packet that describes a router's links and the status of those links. There are separate LSPs for Level 1 and Level 2 updates.

**Neighbor**: A router on the same link with whom routing information is exchanged and an adjacency formed.

**NET (network entity title)**: Part of the OSI address, this describes both the area and system ID of a system in the IS-IS network.

**NPDU (network protocol data unit)**: See PDU.

**NSAP (network service access point)**: Describes a service at the network layer to which the packet is to be directed. The NSAP is the NET address with the SEL field set to a value other than 0x00.

**OL (overload) bit**: The OL is set on an LSP if the router cannot store the entire link state database. When other routers receive LSPs with this bit set, they will not send the router any transit traffic for fear that its routing table is incomplete. If the router is making decisions using incomplete data, its decisions may result in sub optimal paths or even routing loops. Traffic destined for the router can still be sent to the directly connected interfaces of a router transmitting the OL bit in its LSPs

**PDU (Protocol Data Unit)**: A unit of data passed from one layer of the OSI model to the same level on another node. Each layer will prefix the PDU to indicate the sending OSI layer, so that the network layer sends NPDUs and the data link layer sends DLPDUs.

**PSNP (Partial Sequence Number Packets)**: These are sent on point-to-point links to explicitly acknowledge each LSP it receives. A router on a broadcast subnetwork will send a PSNP requesting the LSPs it needs to synchronize its link state database.

**Pseudonode**: The LAN identifier for a broadcast subnetwork. The pseudonode is the System ID of the designated router (DIS) plus the circuit ID. The pseudonode has links to each of the ISs, and each IS has a single link to the pseudonode. The use of the pseudonode reduces the number of links required. Instead of *n*-1 links to each of the other ISs, there is one link per IS. Link state PDUs are generated on behalf of the pseudonode by the DIS to all the connected ISs.

**Routeing domain**: (Author's note: Please note that the spelling of Routeing Domain is not a typo; the ISO committee adopted the British spelling.) This is the same as the administrative domain. It defines the boundaries of a network of interconnected routers operated and managed by the same administrative group.

**SNP (sequence number PDUs)**: These are used to acknowledge the receipt of LSPs and to synchronize link state databases.

**SNPA (subnetwork point of attachment)**: The point at which subnetwork services are provided, rather than the physical tap into the medium.

**Subnetwork**: The data link layer.

**Subnetwork dependent layer**: Interfaces with the data link layer, and hides the different kinds of data link layers from the network layer. This sublayer transmits and receives PDUs from the subnetwork and translates DLPDUs into NPDUs and hands them to the appropriate OSI process. It is also responsible for creating and maintaining adjacencies through the exchange of IS-IS Hello PDUs.

**Subnetwork independent layer**: Interfaces with the transport layer and provides it with network services. It describes how CLNS creates and maintains knowledge of the network by exchanging and processing routing information so that data may be transmitted efficiently to remote destination hosts and handed to the transport layer.

**System ID**: The host address. This is a subset of the NET address, and states the area and host address.

**TLV**: This is the same as a CLV, but some literature refers to the variable length fields as Type/Length/Value in accordance to the IP terminology.

## Similarities Between IS-IS and OSPF

IS-IS and OSPF share a common heritage. They both use a link state technology of SPF based on the Dijsktra algorithm and both have two levels in their hierarchical design. OSPF tends to have been deployed as an enterprise solution, while IS-IS is being used as an ISP solution.

Because OSPF learned many lessons from IS-IS, there are many similarities between the two routing protocols. Although associating IS-IS too closely with OSPF could lead to confusion, a review of their like characteristics can clarify IS-IS. Table S-1 outlines their similarities.

*Table S-1 IS-IS and OSPF Similarities and Terminology Comparison*

| **IS-IS Terminology** | **OSPF Terminology** |
|---|---|
| Area | Stub area |
| Area ID | Area ID |
| Backbone area | Backbone |
| DIS (Designated Intermediate System) | Designated router |
| Domain | Network |
| ES (End System) | Host |
| ES-IS (one of the features of ES-IS) | ARP (Address Resolution Protocol) |
| IS (Intermediate System) | Router |
| ISO Routeing Domain | Autonomous system |
| Level 1 | Internal Non Backbone Stub Area. |
| Level 1-2 | Area border router |
| Level 2 | Backbone |

| | |
|---|---|
| LSP (link state packet) | LSA (link state advertisement) |
| CSNP and PSNP (complete and partial sequence number PDUs) | Link state acknowledgement packet |
| PDU (Protocol Data Unit) | Packet |
| NET (network entity title) | IP destination address (subnet and host) |
| NSAP (network service access point) | IP destination address + IP protocol number |
| Routing technology=link state<br>• Classless routing protocol<br>• Address summarization between areas<br>• Uses a link state database<br>• Acknowledges LSPs<br>• Shortest path is computed using Dijkstra-based SPF algorithm<br>• Hellos create and maintain adjacencies<br>• Hellos and holdtime may be configured | Routing technology=link state<br>• Classless routing protocol<br>• Address summarization between areas<br>• Uses a link state database<br>• Acknowledges LSAs<br>• Shortest path is computed using Dijkstra-based SPF algorithm<br>• Hellos create and maintain adjacencies<br>• Hellos and holdtime may be configured |
| Subnet=data link | Subnet= IP network |
| SNPA (subnetwork point of attachment) | MAC address (machine access control) |
| System ID | Router ID |
| Virtual Link (defined but not supported) | Virtual link |

## Differences Between OSPF and IS-IS

Although OSPF and IS-IS share the same common goals and use the same Link State technology to achieve them, the methods they utilize are slightly different. The key differences are listed in Table S-2.

*Table S-2 IS-IS and OSPF Technical Differences*

| **Technology** | **IS-IS** | **OSPF** |
|---|---|---|
| Areas | • Boundaries defined on the link<br>• A area IS can be in an area as well as in the backbone | • Area boundaries are defined on the router<br>• Interfaces may be in different areas<br>• A router may be in many areas<br>• The IS-IS level 1 area is similar to an OSPF stub area, as it has no knowledge of destinations outside its own area. |
| Designated | • If a new IS becomes active with the same or higher | • A same or higher priority does not dislodge the existing DR |

| | | |
|---|---|---|
| router | priority as the existing DIS, the new IS takes the place of the existing DIS, which results in a flood of LSPs<br>• Adjacencies are created with all ISs on the broadcast media<br>• Each IS sends a multicast LSP to all ISs on the media that is unacknowledged<br>• The DIS sends periodic CSNPs to all IS on the media | • Adjacencies on broadcast media are formed with the DR and BDR only<br>• All LSAs are acknowledged |
| Encapsulation | • IS-IS runs on top of the data link layer (layer 2)<br>• It has its own packet<br>• Fragmentation is the responsibility of IS-IS | • OSPF is an IP application<br>• Has an OSPF header and travels inside an IP packet<br>• Fragmentation is the responsibility of IP |
| LAN flooding | • All ISs maintain adjacencies with all other ISs on a broadcast network<br>• DIS sends CSNP to all ISs<br>• Periodic CSNPs ensure the databases are synchronized | • Multicast updates and Hellos sent to DRs<br>• Unicast acknowledgment sent from DR |
| LSAs | • Two types of LSP<br>• Are CVL encoded<br>• Unrecognized are ignored and flooded<br>• Always flooded across all media by originating IS | • Seven types of LSA<br>• Unrecognized LSAs are not flooded<br>• Many small LSAs for summary and external updates<br>• LSA updates generated by each router |